Life Cycle Assessment
& Environmental Product Declaration

Adbri Cement Products EPD

Programme: The International EPD ® System, www.environdec.com
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Geographical scope: Australia

An EPD should provide current information and may be updated if conditions change. The stated validity is therefore subject to the continued registration and publication at www.environdec.com.

In accordance with ISO 14025:2016, EN15804+A2:2019

EPD® AUSTRALASIA
ENVIRONMENTAL PRODUCT DECLARATION

ECO PLATFORM EPD VERIFIED

ADBRI Building Australia since 1882

Adelaide Brighton Cement Ltd | Cockburn Cement | Northern Cement Limited | MCI | swan CEMENT

Table of contents

Adbri is *Building a Better Australia* with its locally manufactured cement, lime, concrete, aggregates, industrial minerals and concrete products.

About Adbri

We believe in doing business responsibly; keeping our people and communities safe; meeting the needs of our customers; and creating long-term value for our shareholders.

We are committed to a sustainable future
Since our origins in 1882, we have focused on building long-term partnerships that add value. We are a proud Australian company with an extensive local manufacturing presence which allows us to be agile in meeting customer needs.

A proud Australian manufacturer and supplier

As one of Australia's most experienced construction materials companies, we have helped build the foundations of our communities.

Today our 1500+ strong team located across 200 locations, continue to work closely with our customers, partners and communities to develop solutions that enhance the quality of lives of Australians, underpinned by our national footprint, secure supply chain and technical expertise.

Technical expertise you can rely on.

We are committed to supplying innovative and quality products, supported by our leading technical advice. Our in-house technical experts are highly experienced in developing and managing quality control and assurance systems for our industry.

Adbri operates a centralised laboratory complex in Birkenhead (South Australia) that provides leading capability in the Australian heavy construction materials industry.

We were the first Australasian laboratory to commission a robotic quality control cement testing facility which improves testing accuracy and efficiencies.

Our customers are also supported by a national team of in-field technical specialists who work closely with our laboratory-based experts. All our laboratories have achieved ISO 9001 endorsement for Quality Management Systems and our centralised Birkenhead laboratory is also NATA accredited to ISO/IEC 17025 for a range of cementitious, lime, concrete and aggregate test methods.

OUR CEMENT BRANDS

With a range of respected and fully owned brands within the Adbri portfolio, complemented by seven joint venture companies, we have the technical capability, product range, scale, and geographic footprint to deliver on our purpose of *Building a Better Australia*.

Adelaide Brighton Cement Ltd · Cockburn Cement · Northern Cement · MCI · swan CEMENT

This cement EPD covers product manufactured and distributed by our Adelaide Brighton Cement, Cockburn Cement, Northern Cement, Morgan Cement International and Swan Cement brands.

Contributing to a safe, healthy and sustainable future for Australians, our communities and the environment is a fundamental part of Adbri's culture.

Our sustainability approach is built on strong relationships with our people, customers, suppliers, partners, shareholders and the communities in which we operate, coupled with continuous improvement across our value chains.

Cement, lime, concrete, aggregates and masonry are essential materials to the global economy. Our products will play a critical role in the transition to a lower carbon environment, supplying key industries including construction, infrastructure, energy, mining, and agriculture.

Our goal at Adbri is to operate with net zero emissions by 2050.

We recognise that reducing emissions will not be easy as we operate two emissions intensive and hard-to-abate processes: the manufacture of cement and lime. We have already started to reduce our operational greenhouse gas (GHG) emissions, with a 32% reduction from 30 June 2010 to 30 June 2021.

Our Net Zero Emissions Roadmap sets out short and medium-term targets, and our actions to reduce emissions, create new products and collaborate with key partners as we progress our goal of net zero emissions by 2050.

CASE STUDY

Refuse Derived Fuel

Adbri pioneered in the use of refuse derived fuel (RDF) in Australia in 2003. Since then, we've used over 1.3 million tonnes of RDF which has significantly reduced the Group's GHG emissions.

RDF is produced by a third party who processes industrial waste products to produce an alternative fuel source. As well as reducing demand for fossil fuels, it diverts waste from landfill.

Our Environmental Product Declarations

Adbri is committed to a sustainable future and this includes providing transparency about our products' environmental credentials via an Environmental Product Declaration (EPD).

Underpinning our EPDs is a Life Cycle Assessment (LCA) which identifies the environmental footprint throughout the life cycle of a product and is compliant with the ISO standards 14040 and 14044.

Having an EPD allows Adbri to understand the roles and contributions of different materials to the total environmental impacts, thus, meeting market demand for science-based, transparent, and verified environmental product information. Adbri has engaged Edge Environment for the production of this EPD.

This report presents the methodology, data, results, and interpretation of the LCA. The LCA has been through several iterations of internal review to refine the life cycle data and assumptions.

This EPD is a specific EPD for cement products. The results are presented for several indicators and are divided in modules. Each module represents the different life cycle stages. Adbri's cement EPD is cradle-to-gate with options for modules A1-A4.

2 General guidance

EPDs are independently verified documents that include information about the environmental impact of products throughout their life cycle.

EPDs require the completion of a Life Cycle Inventory (LCI), LCA and verification to best practice international and Australian standards.

- LCI is the collection of data on the inputs, processes and outputs within a defined system boundary.
- LCA is the modelling of LCI in accordance with ISO 14040, 14044 and 14025 standards.
- EN 15804+A2:2019: Sustainability of construction works – Environmental Product Declarations – core rules for the product category of construction products.
- General Programme Instructions (GPI) for the International EPD System V3.01 – containing instructions regarding methodology and the content that must be included in EPDs registered under the International EPD System.
- Third party verification of the output of the LCA in the format of an EPD.
- Product Category Rules (PCR) 2019:14, v1.11 – construction products.

EPDs are not always comparable

When comparing EPDs it is important to recognise:

- EPDs within the same product category from different programmes may not be comparable.
- EPDs of construction products may not be comparable if they do not comply with ISO 14025:2006 or if they are produced using different PCRs.
- Understanding the detail is important in comparisons. Expert analysis is required to ensure data is truly comparable to avoid unintended distortions.

Benefits of using this EPD

Results derived from this EPD can be used as a component for customers, for the purpose of compiling their own LCA calculation and modelling for EPDs. The 37 environmental impact indicators align with EN15804 +A2 and are used to support lower carbon concrete initiatives, and to establish the global warming potential of materials used for material selection or decision making.

General information

Programme Information

Programme Operator	EPD Australasia
Address	EPD Australasia Limited 315a Hardy Street Nelson 7010 New Zealand
Website	www.epd-australasia.com
E-mail	info@epd-australasia.com
CEN standard	EN 15804 +A2:2019 serves as the core PCR
Product category rules (PCR) 2019	14 Construction products, Version 1.11, 2021-02-05 Complementary Product Category Rules (C-PCR) to PCR 2019:14 Cement and Building Lime, Version 2022-05-18 Product Group Classification: UN CPC 374
PCR review was conducted by	*The Technical Committee of the International EPD ® System. Chair: Claudia A. Peña. Contact via info@environdec.com*
Independent third-party verification	Independent third-party verification of the declaration and data, according to ISO 14025:2006: ☐ EPD process certification ☒ EPD verification
Third-party verifier	*Epsten Group* *101 Marietta St. NW, Suite 2600, Atlanta, Georgia 30303, USA* *www.epstengroup.com* Accredited by: A2LA, Certificate #3142.03
Procedure for follow-up	Procedure for follow-up of data during EPD validity involves third party verifier: ☐ Yes ☒ No

The EPD owner has the sole ownership, liability, and responsibility for the EPD.

EPDs within the same product category but from different programmes may not be comparable. EPDs of construction products may not be comparable if they do not comply with EN 15804. For further information about comparability, see EN 15804 and ISO 14025.

Company Information

Owner of the EPD	Adbri Limited Level 1 157 Grenfell Street Adelaide SA 5001 +61 8 8223 8000
Description of the organisation	Adbri is a leading Australian construction and building materials company that manufactures and distributes cement, lime, concrete, aggregates, masonry products and industrial minerals. With its origins dating back to 1882, Adbri is a vertically integrated business with a national footprint. The Group employs more than 1,500 people and serves customers in the residential and non-residential construction, engineering construction, infrastructure, alumina production and mining markets through its portfolio of respected brands.
Name and location of production sites	Manufacturing and distribution of Adbri cement products is undertaken in the states of New South Wales (NSW), Western Australia (WA), South Australia (SA), and Northern Territory (NT). In particular, the following plants were included, Port Kembla (NSW), Birkenhead (SA), Munster and Kwinana (WA), and Darwin (NT).

Product Information

Adbri's cement products are produced under a third-party certified manufacturing and supply quality assurance system to ISO 9001. The products covered by this EPD include:

General Purpose Cement (GP)	Exceeds the minimum specification for Type GP cement given in AS 3972. GP cement is ideal for use in structural concrete, mortars, renders, grouts, and cement based products. It can also be used as general binder in applications such as soil stabilisation.
Shrinkage Limited Cement (SL)	A special purpose cement which complies with the minimum specification required in AS 3972 for Type SL cement. When combined with good concrete mix design practice, SL cement can result in improved concrete drying shrinkage.
Minecem (MCM)	A specially formulated binder is used in underground backfilling applications and can also be used as a general binder in applications such as soil stabilisation.
Granulated Blast Furnace Slag Cement	Exceeds the minimum specification for Type GB cement given in AS 3972. GBS is often used in place of General Purpose cement (GP) when early strength development is not critical.
Low Heat Cement (LH)	Exceeds the minimum specification for Types LH, SR, and GB cement given in AS 3972. LH cement is ideal for use in mass-fill structural pours where there is a need to control the rate of internal concrete temperature rise (heat of hydration) in order to reduce the risk of thermal cracking. It can also be used in concretes and mortars where the possibility of attack by sulfate bearing waters and soils is high.

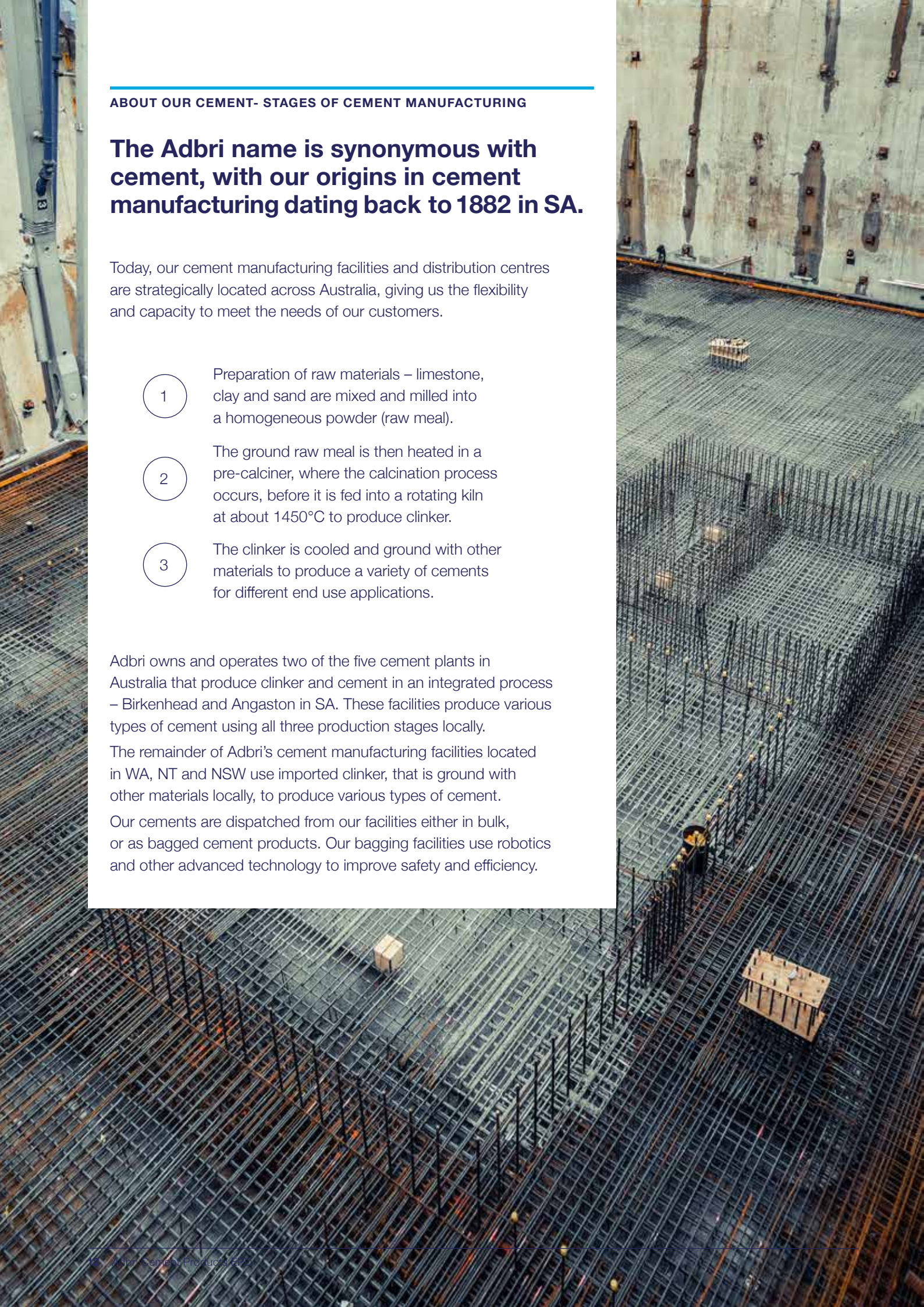
Product Identification

General purpose and blended cements are manufactured to comply with AS3972.

Minecem is a specially formulated binder for use in underground backfilling applications and can also be used as a general binder in applications such as soil stabilisation and other low strength applications.

Product Description

Adbri has developed a Life Cycle Assessment (LCA) and Environmental Product Disclosure (EPD) for their cement products manufactured over four states of Australia. The following products included in this EPD; General Purpose Cement (GP), Shrinkage Limited Cement (SL), Minecem (MCM), Granulated Blast Furnace Slag Cement (GBS) and Low Heat Cement (LH).



ABOUT OUR CEMENT- STAGES OF CEMENT MANUFACTURING

The Adbri name is synonymous with cement, with our origins in cement manufacturing dating back to 1882 in SA.

Today, our cement manufacturing facilities and distribution centres are strategically located across Australia, giving us the flexibility and capacity to meet the needs of our customers.

1. Preparation of raw materials – limestone, clay and sand are mixed and milled into a homogeneous powder (raw meal).
2. The ground raw meal is then heated in a pre-calciner, where the calcination process occurs, before it is fed into a rotating kiln at about 1450°C to produce clinker.
3. The clinker is cooled and ground with other materials to produce a variety of cements for different end use applications.

Adbri owns and operates two of the five cement plants in Australia that produce clinker and cement in an integrated process – Birkenhead and Angaston in SA. These facilities produce various types of cement using all three production stages locally.

The remainder of Adbri's cement manufacturing facilities located in WA, NT and NSW use imported clinker, that is ground with other materials locally, to produce various types of cement.

Our cements are dispatched from our facilities either in bulk, or as bagged cement products. Our bagging facilities use robotics and other advanced technology to improve safety and efficiency.

The most common use of Adbri's cement products is for the production of concrete which is a mixture of cement, water, sand and aggregates, as well as supplementary cementitious materials (SCMs) which help to improve the sustainability and durability properties of finished products.

The presence of strong and sustainable local manufacturing of key materials such as cement and concrete is closely linked to the economic prosperity of Australia and its regional communities.

Figure 1 | Cement process flow

4 LCA information

Four types of cement have been assessed in the LCA study. These mixes have differences in terms of compositions and the amount of components. Table 1 shows the cement name and relevant manufactured location.

Declared unit and Reference Service Life (RSL)

The declared unit adopted is 1 tonne of manufactured cement, which fulfills the specified quality criteria during its Reference Service Life (RSL). The RSL is not specified as the scope is cradle-to-gate, and there are a variety of applications of cement with different anticipated RSLs.

Databases and LCA software used

The software used was SimaPro® LCA software (v 9.1.1.1). The inventory data for the processes are entered in the LCA software and linked to the pre-existing background data for upstream feedstocks and services. Inventory data was selected per the standards, in the following order of preference:

1. The Australian Life Cycle Inventory Shadow Database (AusLCI shadow database) v1.31 being compiled by the Australian Life Cycle Assessment Society (ALCAS) – this data will comply with the AusLCI Data Guidelines (Australian Life Cycle Inventory Database Initiative (AusLCI), 2019). At the time of this report, the AusLCI shadow database was 3 years old.[1]
2. The Australian Life Cycle Inventory (AusLCI) v1.28 being compiled by the Australian Life Cycle Assessment Society (ALCAS) – this data will comply with the AusLCI Data Guidelines (Australian Life Cycle Inventory Database Initiative (AusLCI), 2019). At the time of this report, the AusLCI database was 3 years old.[2]
3. Ecoinvent 3.6 database (Ecoinvent Centre, 2019) for all processes taking place overseas i.e. outside Australia, using global average processes. At the time of this report, the Ecoinvent database was 3 years old.[3]

Description of system boundaries and excluded life cycle stages

The scope of LCA for this EPD is cradle-to-gate with options for modules A1-A4. Emissions from construction installation (A5) were excluded as cement will be used as a mix component in manufacturing for other products (e.g. concrete and masonry) and cement cannot be physically separated from other products at end of life. In addition, the following life cycle stages were also excluded because cement is not directly used as a standalone product: use stages (B1-B7), end of life stages (C1-C4), and reuse-recycling stage (D).

All modules included in this EPD are marked as X in the table below and those excluded are marked as 'Module not declared' (MND). The system boundary for this EPD is depicted in figure 2.

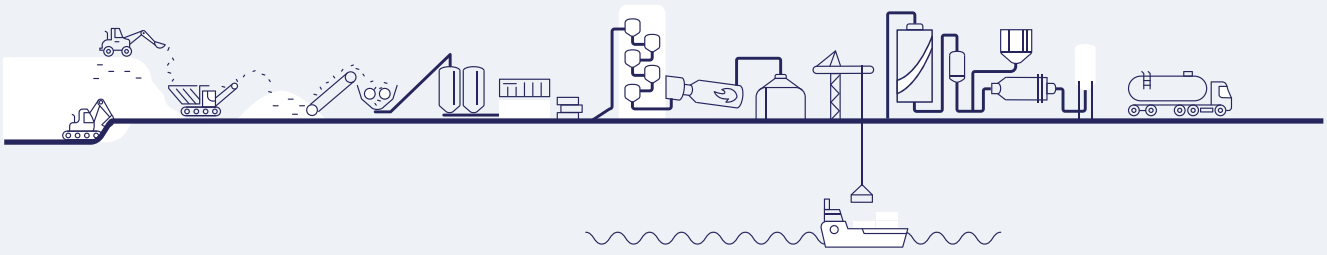
Cement name	Manufactured plant	State
GP	Birkenhead	SA
	Munster	WA
	Kwinana	WA
	Darwin	NT
GBS	Birkenhead	SA
MCM	Birkenhead	SA
	Munster	WA
SL	Port Kembla	NSW
LH	Darwin	NT

Table 1 | Cement assessed in this study

GPI module		Asset life cycle stage	Information module	Declared modules
Upstream	**A1**	Raw material supply	**A1-3.** Manufacturing stage	X
Core	**A2**	Transport		X
	A3	Manufacturing		X
Downstream	**A4**	Transport	**A4-5.** Construction stage	X
	A5	Construction, installation process		MND
	B1	Material emissions from usage	**B.** Usage stage	MND
	B2	Maintenance		MND
	B3	Repair		MND
	B4	Replacement		MND
	B5	Refurbishment		MND
	B6	Operational energy use		MND
	B7	Operational water use		MND
	C1	Deconstruction and demolition	**C.** End of life	MND
	C2	Transport		MND
	C3	Waste Processing		MND
	C4	Disposal		MND
Other environmental information	**D**	Reuse, recycle or recovery	**D.** Recyclability potentials	MND

Table 2 | Life cycle of building products: stages and modules included in this EPD

System diagram



The processes included in the LCA are presented in a process diagram in the figure below:

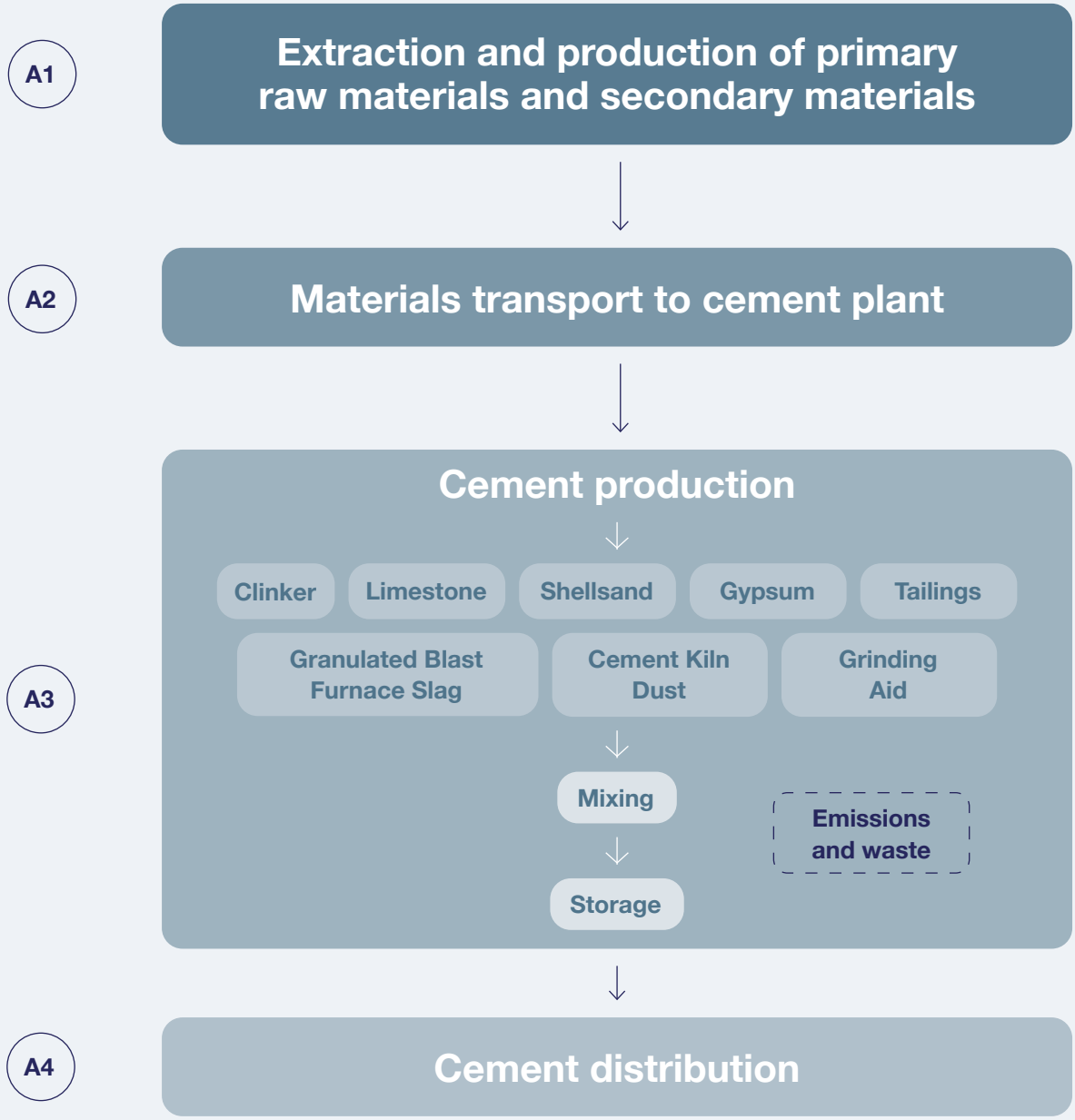


Figure 2 | System diagram

Upstream processes

The upstream processes include those involved in Module A1 – Raw material supply.
This module includes:

- Extraction, transport and manufacturing of raw materials.
- Generation of electricity from primary and secondary energy resources, also including their extraction, refining and transport for Modules A1 and A3.

Electricity inputs in foreground processes based in Australia were modelled based on the state-specific grid. The AusLCI database was used to model electricity in the foreground processes. The AusLCI dataset was updated using state specific grid data sourced from the Department of the Environment and Energy (Department of the Environment and Energy, December 2020).

Core processes

The core processes include those involved in Module A2 and Module A3, including:

- External transportation of materials to the core processes and internal transport.
- Manufacturing of the cement mixes.
- Treatment of external recycled materials for reuse.

Data quality

Foreground data on raw material requirements, manufacture, construction, use and end of life inputs is for FY2020-2021. The data sources and their assessed quality are detailed in Table 2. Overall, the data quality for this LCA was considered high. The EPD will be updated if changes in its life cycle inventory lead to a variation of 10% or more in any of the included environmental indicators during its validity period.

Material description	Input/Output	Data source	Temporal scope	Quality
A1	Clinker	Cement mix designs, sourced from the engineering site manager of each plant (Adbri)	FY2020-2021	High
	Limestone			
	Sand			
	Gypsum			
	Granulated Blast Furnace Slag			
	Gypsum			
	Cement Kiln Dust			
	Tailings			
	Grinding Aids			
A2	Transport distances from raw material suppliers to Adbri's manufacturing sites	Sourced from the engineering site manager of each plant (Adbri)	FY2020-2021	High
A3	Electricity and natural gas used for manufacturing of cement products	NPI Report, sourced from the engineering site manager of each plant (Adbri)	FY2020-2021	High
A4	Transport distances from Adbri's cement manufacturing sites to Adbri's masonry or concrete manufacturing sites or other clients	Sourced from the sales manager (Adbri)	FY2020-2021	High

Table 3 | Data quality

Cut-off rules and exclusion of small amounts

It is common practice in LCA/LCI protocols to propose exclusion limits for inputs and outputs that fall below a threshold percentage of the total, but with the exception that where the input/output has a "significant" impact it should be included. According to the PCR 2019:14 v1.11, life cycle inventory data, shall according to EN 15804 A2, include a minimum of 95% of total inflows (mass and energy) per module. Inflows not included in the LCA shall be documented in the EPD. Data gaps in included stages in the downstream modules shall be reported in the EPD, including an evaluation of their significance. In accordance with the PCR 2019:14 v1.11, the following system boundaries are applied to manufacturing equipment and employees:

- Environmental impact from infrastructure, construction, production equipment, and tools that are not directly consumed in the production process are not accounted for in the LCI. Capital equipment and buildings typically account for less than a few percent of nearly all LCIs and this is usually smaller than the error in the inventory data itself. For this project, it is assumed that capital equipment makes a negligible contribution to the impacts as per Frischknecht, 2007 with no further investigation.
- Personnel-related impacts, such as transportation to and from work, are also not accounted for in the LCI. The impacts of employees are also excluded from inventory impacts on the basis that if they were not employed for this production or service function, they would be employed for another. It is very hard to decide what proportion of the impacts from their whole lives should count towards their employment. For this project, the impacts of employees are excluded.
- Transport for raw materials accounting for less than 1% of the feedmix was excluded. This is because the impact contribution is considerably small.

Based on this guidance, no energy or mass flows, except packaging of materials were excluded. All materials required for manufacturing are delivered via trucks and ships without packaging.

Allocation

According to the PCR 2019:14 v1.11 for Construction Products, in a process step where more than one type of product is generated, it is necessary to divide the unit process into different subprocesses that can be allocated to the co-products and collecting the input and output data related to these subprocesses.

In the case of co-production, where the processes cannot be subdivided the coherence of the process must be followed. The allocation procedure criteria is as follows:

Revenue Classification	Revenue Contribution	Allocation Type
Very Low	Processes generating overall revenue of the order of 1% or less	The process may be neglected
High	A difference in revenue of more than 25	Allocation shall be based on economic values
Low	A difference in revenue of less than 25%	Allocation shall be based on physical properties, e.g. mass, volume.

Table 4 | Allocation procedure criteria

Material flow carrying specific inherent properties, e.g. energy content, elementary composition, shall always be allocated reflecting the physical flows, irrespective of the allocation chosen for the process.

In the case of combined heat and power production, a distribution based on the best efficiency for the (potential) separate generation of electricity or heat shall be considered.

Data provided by Adbri for this assessment includes both product (recycled content in mixes) and production site (energy use) specific data.

Allocation of recycled content in granulated blast furnace slag, cement kiln dust and tailings

Adbri's cement mixes incorporate varying levels of supplementary cementitious materials, i.e. granulated blast furnace slag, dust and tailings. BS EN 16757:2017 specifically lists these materials relevant to the study as co-products. As such, the above materials are considered as co-products of their production process and the impacts for their production process are allocated according to PCR 2014:19 Construction Products (co-produced goods, multi-output allocation).

Ground granulated blast furnace slag: The AusLCI process for slag is allocated based on economic value as the product has significant economic value at the point of collection.

Cement kiln dust: Similar to fly ash in the AusLCI process, cement kiln dust is treated as a waste material and only includes transport impacts. If the dust was not utilised as a supplementary cementitious material, this material would otherwise have been landfilled and hence, classified as waste.

Tailings: Tailings are a by-product of the mining process after materials of value are extracted. Similar to fly ash in the AusLCI process, tailings are treated as waste materials and only include transport impacts.

Allocation of production site specific data will be discussed in sections 4.4.1 and 4.4.2.

Allocation in background data

The allocation approach for the generic databases utilised in this LCA is also compliant with the PCR. More specifically, the burden of primary production of materials is always allocated to the primary user of a material, while secondary (recycled) materials bear only the impacts of the recycling processes.

The allocation approach of the AusLCI LCA database was adopted as a default for secondary data and processes (e.g. secondary fuel in cement production). The AusLCI dataset conforms to EN 15804 when applying allocation to its various processes and sub-processes.

Compliance with standards

The LCA and EPD have been developed to comply with:

1. BS EN 15804:2012+A2:2019. Sustainability of construction works. Environmental product declarations. Core rules for the product category of construction products. British Standards Institution, 2019.[3]
2. BS EN 16757:2017. Sustainability of construction works – Environmental product declarations – Product Category Rules for concrete and concrete elements. British Standards Institution, 2017.[4]
3. ISO 14040:2006 and ISO14044:2006+A1:2018 which describe the principles, framework, requirements and provides guidelines for life cycle assessment (LCA) (ISO, 2006; ISO, 2018).[7-8]
4. ISO 14025:2006 Environmental labels and declarations – Type III environmental declarations -- Principles and procedures, which establishes the principles and specifies the procedures for developing Type III environmental declaration programmes and Type III environmental declarations (ISO, 2006).[9]
5. General Programme Instructions (GPI) for the International EPD System V3.01 – containing instructions regarding methodology and the content that must be included in EPDs registered under the International EPD System.[10]
6. PCR 2019:14 Construction Products (Version 1.11), 2021-02-05.[11]
7. Complementary Product Category Rules (C-PCR) to PCR 2019:14 Cement and Building Lime, Version 2022-05-18.[12]

Key assumptions: All foreground data used for the manufacturing processes (up to factory gate), transportation to the cement plant, distribution in Australia, via a 'Request for Information' spreadsheet. This data was collected for the period September 2020 to September 2021 referred as financial year 2020 -2021 (FY20-21).

5 Content declaration

EPD product description

Four types of cement with varying mix designs have been included in this EPD. These mixes have differences in term of compositions and amount of components (see table 5).

Table 5 | Percentage of material composition included in this EPD

Material description	Birkenhead	Munster	Kwinana	Port Kembla	Darwin
Clinker	28 – 89%	33 – 88%	90 – 93%	88 – 90%	30 – 89%
SCMs	28 – 60%	0 – 62%	0%	0%	5 – 63%
Limestone	1 – 6%	1 – 7%	0 – 2%	1 – 6%	0 – 3%
Gypsum	5 – 7%	4 – 6%	3 – 5%	3 – 5%	4 – 7%
Cement Kiln Dust	0 – 3%	0%	0%	0%	0%
Grinding Aid	<1%	<1%	<1%	<1%	<1%

The material composition for each of these mixes is shown in Table 6. All the materials used for cement mixes were transported via truck and ship. All materials used in manufacturing of cement are delivered in bulk via trucks and ships and no packaging material is involved. Table 6 provides an overview of the raw material transport type and kg.km transported according to the material quantities.

Table 6 | Summary of materials transport (kg per tonne of cement)

Plant	Materials	Ship (kg.km)	Truck (kg.km)	Route description
Adelaide Brighton Cement (Birkenhead)	Clinker	8.58E+03	5.30E+00	Kanda - (SHIP) - Adelaide - (TRUCK) - Birkenhead
	Blast Furnace Slag	8.58E+03	5.30E+00	Japan - (SHIP) - Adelaide - (TRUCK) - Birkenhead
	Limestone	1.37E+08	-	Klein Point - (SHIP) - Birkenhead
	Gypsum	-	1.36E+07	Blanchetown - (TRUCK) - Birkenhead
Cockburn Cement (Kwinana)	Clinker	6.88E+03	1.50E+00	Japan - (SHIP) - Kwinana - (TRUCK) - Kwinana
	Blast Furnace Slag	6.88E+03	1.50E+00	Japan - (SHIP) - Kwinana - (TRUCK) - Kwinana
	Gypsum	-	3.00E+02	Kalannie - (TRUCK) - Kwinana
Cockburn Cement (Munster)	Clinker	6.88E+03	1.05E+01	Kanda - (SHIP) - Kwinana - (TRUCK) - Munster
	Blast Furnace Slag	6.88E+03	1.05E+01	Japan - (SHIP) - Kwinana - (TRUCK) - Munster
	Gypsum	-	3.00E+02	Kalannie - (TRUCK) - Munster
Morgan Cement (Port Kembla)	Clinker - Imported	7.14E+03	2.00E+00	Tsukumi - (SHIP) - Pt Kembla
	Clinker - External	-	9.4E+01	Berrima - (TRUCK) - Pt Kembla
	Limestone	-	1.45E+02	Marulan - (TRUCK) - Pt Kembla
	Gypsum	-	1.99E+03	Thevenard - (TRUCK) - Pt Kembla
Northern Cement (Darwin)	Clinker	4.60E+03	3.00E+00	Japan (SHIP) - Darwin (TRUCK) - Darwin
	Blast Furnace Slag	4.60E+03	3.00E+00	Japan (SHIP) - Darwin (TRUCK) - Darwin
	Limestone	-	4.25E+02	Mataranka - (TRUCK) - Darwin
	Gypsum	4.84E+03	3.00E+00	Bangkok - (SHIP) - Darwin - (TRUCK) - Darwin

Manufacturing of cement is undertaken at five plants as listed in Table 7. The electricity used for cement production was collected from FY20 National Pollution Inventory (NPI) report and was modelled based on the state specific grid. The AusLCI database was used to model electricity in the foreground processes.

Consumption of diesel, unleaded petrol, LPG, and natural gas was based on NPI and National Greenhouse and Energy Reporting (NGER).

The data of waste materials was provided by Adbri, including:

- Transport of waste materials, off spec and spills generated at manufacturing plants to landfill and recycling facility.
- Treatment of materials, off spec and spills generated at manufacturing plants for landfilling and recycling.

The data of emissions generated at manufacturing plants was based on NGER report.

Data regarding distribution of manufactured cement was calculated based on annual figures provided by Adbri, including transport modes and distance. Table 8 summarises the data provided for distance between manufacture site and consumers, and modelled data for assessment.

Table 7 | Utilities used for manufacturing for Adbri cement products (per t of cement)

Utilities	Description	Unit	Birkenhead	Munster	Kwinana	Port Kembla	Darwin
Electricity - grid	Electricity	kWh	9.02E+07	2.43E+07	2.51E+07	2.29E+04	8.21E+06
Fuels	Diesel	kL	0.00E+00	1.82E+02	4.98E+02	2.65E+04	4.43E+01
Fuels	Unleaded petrol	kL	0.00E+00	5.00E+00	0.00E+00	0.00E+00	0.00E+00
Fuels	LPG	L	0.00E+00	0.00E+00	5.35E+04	1.65E+03	0.00E+00
Fuels	Natural gas	MJ	0.00E+00	0.00E+00	6.12E+07	0.00E+00	1.30E+07

Table 8 | Average distance for distribution per tonne of cement

Plant/State	Cement type	Average distance road (tkm)
Darwin/NT	Shrinkage limited (SL) or Low heat (LH)	5.31E+00
	GP	2.19E+02
Port Kembla/NSW	Morgan Cement SL	8.45E+02
Birkenhead/SA	ABC GBS	2.72E+02
	ABC GP	6.37E+02
	ABC MineCem	4.71E+02
Munster/WA	Cockburn Cement GP	1.60E+02
	Cockburn Cement MineCem	3.07E+01
Kwinana/WA	Cockburn Cement GP	1.08E+02

Environmental performance

The potential environmental impacts, use of resources and waste categories included in this EPD were calculated using the SimaPro v9.1.1.1 tool and are listed in Table 9. All tables from this point will contain the abbreviation only.

The LCA results are relative expressions and do not predict impacts on category endpoints, the exceeding of thresholds and safety margins or risks. The impact assessment results are presented in the next sections.

Table 9 | Life cycle impact, resource and waste assessment categories, measurements and methods.

Impact category	Abbreviation	Measurement unit	Assessment method and implementation	Disclaimer
POTENTIAL ENVIRONMENTAL IMPACTS				
Global warming potential (fossil)	GWPF	kg CO2 equivalents (GWP100)	Baseline model of 100 years of the IPCC based on IPCC 2013	None
Global warming potential (biogenic)	GWPB	kg CO2 equivalents (GWP100)	Baseline model of 100 years of the IPCC based on IPCC 2013	None
Global warming potential (land use/ land transformation)	GWPL	kg CO2 equivalents (GWP100)	Baseline model of 100 years of the IPCC based on IPCC 2013	None
Total global warming potential	GWPT	kg CO2 equivalents (GWP100)	Baseline model of 100 years of the IPCC based on IPCC 2013	None
Acidification potential	AP	mol H+ eq.	Accumulated Exceedance, Seppälä et al. 2006, Posch et al., 2008	None
Eutrophication – aquatic freshwater	EP - freshwater	kg PO43- equivalents	CML (v4.1)	None
Eutrophication – aquatic freshwater	EP - freshwater	kg P equivalent	EUTREND model, Struijs et al., 2009b, as implemented in ReCiPe[1]	None
Eutrophication – aquatic marine	EP - marine	kg N equivalent	EUTREND model, Struijs et al., 2009b, as implemented in ReCiPe	None
Eutrophication – terrestrial	EP – terrestrial	mol N equivalent	Accumulated Exceedance, Seppälä et al. 2006, Posch et al.	None
Photochemical ozone creation potential	POCP	kg NMVOC equivalents	LOTOS-EUROS ,Van Zelm et al., 2008, as applied in ReCiPe	None
Abiotic depletion potential (elements)	ADPE	kg Sb equivalents	CML (v4.1)	2
Abiotic depletion potential (fossil fuels)	ADPF	MJ net calorific value	CML (v4.1)	2
Ozone depletion potential	ODP	kg CFC 11 equivalents	Steady-state ODPs, WMO 2014	None
Water Depletion Potential	WDP	m3 equivalent deprived	Available WAter REmaining (AWARE) Boulay et al., 2016	2

Impact category	Abbreviation	Measurement unit	Assessment method and implementation	Disclaimer
ADDITIONAL ENVIRONMENTAL IMPACTS				
Global warming potential, excluding biogenic uptake, emissions and storage	GWP-GHG	kg CO2 equivalents (GWP100)	CML (v4.1)	None
Particulate matter	PM	disease incidence	SETAC-UNEP, Fantke et al. 2016 [2]	None
Ionising radiation - human health	IRP	kBq U-235 eq	Human health effect model as developed by Dreicer et al. 1995 update by Frischknecht et al., 2000	1 (Refer to the bottom of the table)
Eco-toxicity (freshwater)	ETP-fw	CTUe	Usetox version 2 until the modified USEtox model is available from EC-JRC	2 (Refer to the bottom of the table)
Human toxicity potential - cancer effects	HTP-c	CTUh	Usetox version 2 until the modified USEtox model is available from EC-JRC	2 (Refer to the bottom of the table)
Human toxicity potential - non cancer effects	HTP-nc	CTUh	Usetox version 2 until the modified Usetox model is available from EC-JRC	2 (Refer to the bottom of the table)
Soil quality	SQP	dimensionless	Soil quality index based on LANCA	2 (Refer to the bottom of the table)
RESOURCE USE				
Use of renewable primary energy excluding renewable primary energy resources used as raw materials	PERE	MJ, net calorific value	ecoinvent version 3.6 and expanded by PRé Consultants[5 6]	None
Use of renewable primary energy resources used as raw materials	PERM	MJ, net calorific value	Manual for direct inputs[7]	None
Total use of renewable primary energy resources (primary energy and primary energy resources used as raw materials)	PERT	MJ, net calorific value	ecoinvent version 3.6 and expanded by PRé Consultants[8]	None
Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials	PENRE	MJ, net calorific value	Manual for direct inputs[9]	None
Use of non- renewable primary energy resources used as raw materials	PENRM	MJ, net calorific value	ecoinvent version 3.6 and expanded by PRé Consultants	None
Total use of non-renewable primary energy resources (primary energy and primary energy resources used as raw materials)	PENRT	MJ, net calorific value	ecoinvent version 3.6 and expanded by PRé Consultants[10]	None
Use of secondary material	SM	kg	Manual for direct inputs	None
Use of renewable secondary fuels	RSF	MJ, net calorific value	Manual for direct inputs	None

Impact category	Abbreviation	Measurement unit	Assessment method and implementation	Disclaimer
Use of non-renewable secondary fuels	NRSF	MJ, net calorific value	Manual for direct inputs	None
Use of net fresh water	FW	m3	ReCiPe 2016	None
WASTE CATEGORIES				
Hazardous waste disposed	HWD	kg	EDIP 2003 (v1.05)	None
Non-hazardous waste disposed	NHWD	kg	EDIP 2003 (v1.05)[11]	None
Radioactive waste disposed/stored	RWD	kg	EDIP 2003 (v1.05)	None
OUTPUT FLOWS				
Components for reuse	CRU	kg	Manual for direct inputs	None
Materials for recycling	MFR	kg	Manual for direct inputs	None
Materials for energy recovery	MFRE	kg	Manual for direct inputs	None
Exported energy	EE	MJ per energy carrier	Manual for direct inputs	None

Disclaimer 1 – This impact category deals mainly with the eventual impact of low dose ionizing radiation on human health of the nuclear fuel cycle. It does not consider effects due to possible nuclear accidents, occupational exposure nor due to radioactive waste disposal in underground facilities. Potential ionising radiation from the soil, from radon and from some construction materials is also not measured by this indicator.[12]

Disclaimer 2 – The results of this environmental impact indicator shall be used with care as the uncertainties on these results are high, or as there is limited experience with the indicator.

[1] EN 15804:2012+A2:2019 specifies that the unit for the indicator for Eutrophication aquatic freshwater shall be kg PO43- eq, although the reference given ("EUTREND model, Struijs et al., 2009b, as implemented in ReCiPe") uses the unit kg P eq. This is likely a typographical error in EN 15804+A2, which is expected to be corrected in a future revision. Until this has been corrected, results for Eutrophication aquatic freshwater shall be given in both kg PO4 eq and kg P eq. in the EPD.

[2] Fantke et al., Global Guidance for Life Cycle Impact Assessment Indicators: Volume 1. UNEP/SETAC Life Cycle Initiative, Paris, pp. 76-99.

[3] Dreicer et al., 1995. ExternE, Externalities of Energy, Vol. 5. Nuclear, Science, Research and Development JOULE, Luxembourg.

[4] Frischknecht et al., R., 2000. Environmental impact assessment Review, 20, pp.159-189.

[5-6] Method to calculate Cumulative Energy Demand (CED), based on the method published by Ecoinvent version 2.0 and expanded by PRé Consultants for raw materials available in the SimaPro database.

[7] Calculated based on the lower heating value of renewable raw materials.

[8] Calculated as sum of renewable, biomass, renewable, wind, solar, geothermal and renewable, water.

[9] Calculated based on the higher heating value of non-renewable raw materials.

[10] Calculated as sum of non-renewable, fossil, non-renewable, nuclear and non-renewable, biomass.

[11] Calculated as sum of bulk waste and slags/ash.

[12] Aligned with PCR 2019:14.

Environmental performance results

Modules A1 to A4
Product stage (A1-A3) results per tonne of cement

	ENVIRONMENTAL IMPACT													
	GWP - F	GWP - B	GWP - Luluc	GWP - T	ODP	AP	EP-fw	EP-fw*	EP-mar	EP-ter	POCP	ADPE	ADPF	WDP
TYPES OF CEMENT	kg CO2 eq	kg CO2 eq	kg CO2 eq	kg CO2 eq	kg CFC 11 eq.	mol H+ eq.	kg PO43- eq.	kg P eq.	kg N eq.	mol N eq.	kg NMVOCeq.	kg Sb eq.	MJ	m^3 eq.
LH/Darwin	503	2.75E-01	3.31E-04	503	1.42E-05	2.86E+00	2.74E-01	2.81E-03	7.13E-01	7.95E+00	2.05E+00	9.74E-05	3.12E+03	2.20E+03
GP/Darwin	1024	9.81E-02	6.79E-04	1024	2.78E-05	3.95E+00	4.79E-01	2.72E-03	1.24E+00	1.40E+01	3.50E+00	7.59E-05	4.19E+03	1.68E+03
SL/Port Kembla	947	-4.58E-02	6.11E-04	947	2.40E-05	3.59E+00	4.18E-01	2.65E-03	1.06E+00	1.19E+01	3.04E+00	8.22E-05	3.64E+03	1.48E+03
MCM/Birkenhead	385	2.39E-01	1.25E-03	385	2.32E-05	4.18E+00	4.48E-01	7.36E-03	1.20E+00	1.33E+01	3.47E+00	7.17E-04	4.22E+03	3.57E+03
GP/Birkenhead	696	1.36E-01	3.39E-03	696	4.77E-05	6.90E+00	9.65E-01	1.60E-02	2.59E+00	2.89E+01	7.41E+00	1.94E-03	7.76E+03	5.28E+03
GBS/Birkenhead	558	1.90E-01	2.42E-03	558	3.67E-05	5.69E+00	7.31E-01	1.22E-02	1.96E+00	2.18E+01	5.62E+00	1.39E-03	6.22E+03	4.57E+03
MCM/Munster	509	1.77E-01	3.84E-04	510	1.67E-05	3.07E+00	3.02E-01	2.98E-03	7.82E-01	8.73E+00	2.26E+00	9.44E-05	2.70E+03	2.21E+03
GP/Munster	992	-2.31E-03	6.65E-04	992	2.69E-05	3.83E+00	4.84E-01	2.74E-03	1.24E+00	1.38E+01	3.49E+00	7.06E-05	3.44E+03	1.57E+03
GP/Kwinana	1098	1.82E-01	7.01E-04	1098	2.84E-05	4.35E+00	5.42E-01	3.06E-03	1.40E+00	1.56E+01	3.93E+00	9.41E-05	4.03E+03	1.78E+03

Table 10 | Mix GP, GB, MCM and SL (LH) environmental impact A1-A3 per tonne of cement: EPD potential environmental impacts

	RESOURCE USE									
	PERE	PERM	PERT	PENRE	PENRM	PENRT	SM	RSF	NRSF	FW
TYPES OF CEMENT	MJ	MJ	MJ	MJ	MJ	MJ	kg	MJ	MJ	m3
LH/Darwin	7.84E+01	0.00E+00	7.84E+01	3.20E+03	0.00E+00	3.20E+03	0.00E+00	0.00E+00	0.00E+00	1.87E-01
GP/Darwin	5.83E+01	0.00E+00	5.83E+01	4.34E+03	0.00E+00	4.34E+03	0.00E+00	0.00E+00	0.00E+00	2.76E-01
SL/Port Kembla	7.42E+01	0.00E+00	7.42E+01	3.77E+03	0.00E+00	3.77E+03	7.31E+00	4.30E+01	0.00E+00	3.27E-01
MCM/Birkenhead	1.76E+02	0.00E+00	1.76E+02	4.34E+03	0.00E+00	4.34E+03	0.00E+00	0.00E+00	0.00E+00	4.62E-01
GP/Birkenhead	1.90E+02	0.00E+00	1.90E+02	8.01E+03	0.00E+00	8.01E+03	0.00E+00	0.00E+00	0.00E+00	1.10E+00
GBS/Birkenhead	1.85E+02	0.00E+00	1.85E+02	6.41E+03	0.00E+00	6.41E+03	0.00E+00	0.00E+00	0.00E+00	8.12E-01
MCM/Munster	5.75E+01	0.00E+00	5.75E+01	2.79E+03	0.00E+00	2.79E+03	0.00E+00	0.00E+00	0.00E+00	2.05E-01
GP/Munster	3.51E+01	0.00E+00	3.51E+01	3.58E+03	0.00E+00	3.58E+03	0.00E+00	0.00E+00	0.00E+00	2.77E-01
GP/Kwinana	6.79E+01	0.00E+00	6.79E+01	4.18E+03	0.00E+00	4.18E+03	0.00E+00	0.00E+00	0.00E+00	2.98E-01

Table 11 | Mix GP, GB, MCM and SL (LH) environmental impact A1-A3 per tonne of cement: EPD potential environmental impacts: EPD resource parameters

	WASTE CATEGORIES		
	HWD	NHWD	RWD
TYPES OF CEMENT	kg	kg	kg
LH/Darwin	2.31E-03	9.44E+00	5.73E-05
GP/Darwin	1.33E-03	8.33E+00	1.61E-04
SL/Port Kembla	1.08E-03	4.49E+00	1.08E-03
MCM/Birkenhead	4.51E-03	7.34E+03	1.40E-05
GP/Birkenhead	7.61E-03	2.30E+04	3.05E-05
GBS/Birkenhead	6.23E-03	1.58E+04	2.33E-05
MCM/Munster	2.30E-03	5.03E+00	6.33E-05
GP/Munster	1.16E-03	3.73E+00	1.59E-04
GP/Kwinana	1.47E-03	4.56E+00	1.69E-04

Table 12 | Mix GP, GB, MCM and SL (LH) environmental impact A1-A3 per tonne of cement: EPD potential environmental impacts: EPD waste categories

	OUTPUT FLOWS			
	CRU	MFR	MFRE	EE
TYPES OF CEMENT	kg	kg	kg	MJ
LH/Darwin	0.00E+00	0.00E+00	0.00E+00	0.00E+00
GP/Darwin	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SL/Port Kembla	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MCM/Birkenhead	0.00E+00	0.00E+00	0.00E+00	0.00E+00
GP/Birkenhead	0.00E+00	0.00E+00	0.00E+00	0.00E+00
GBS/Birkenhead	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MCM/Munster	0.00E+00	0.00E+00	0.00E+00	0.00E+00
GP/Munster	0.00E+00	0.00E+00	0.00E+00	0.00E+00
GP/Kwinana	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table 13 | Mix GP, GB, MCM and SL (LH) environmental impact A1-A3 per tonne of cement: EPD potential environmental impacts: output flow categories

	ADDITIONAL ENVIRONMENTAL IMPACT INDICATORS						
	GWP-GHG	PM	Ionising radiation	Ecotoxicity, freshwater	Human toxicity, cancer	Human toxicity, non-cancer	Soil quality
TYPES OF CEMENT	kg CO2 eq.	disease incidence	kBq U-235 eq	CTUe	CTUh	CTUh	Pt
LH/Darwin	497	1.12E-05	4.49E-01	3.19E+03	5.13E-08	2.93E-06	5.55E+02
GP/Darwin	1016	1.47E-05	1.27E+00	6.90E+03	9.24E-08	5.70E-06	7.03E+02
SL/Port Kembla	812	1.28E-05	1.04E+00	1.15E+04	1.19E-07	7.83E-06	4.80E+02
MCM/Birkenhead	376	1.59E-05	9.92E-02	2.43E+03	8.15E-08	4.25E-06	1.09E+03
GP/Birkenhead	676	2.78E-05	2.17E-01	5.11E+03	1.76E-07	9.79E-06	2.25E+03
GBS/Birkenhead	543	2.25E-05	1.65E-01	3.90E+03	1.33E-07	7.27E-06	1.72E+03
MCM/Munster	505	1.14E-05	4.96E-01	3.72E+03	5.96E-08	3.36E-06	4.72E+02
GP/Munster	985	1.46E-05	1.25E+00	7.70E+03	9.88E-08	6.12E-06	5.67E+02
GP/Kwinana	1090	1.88E-05	1.33E+00	8.67E+03	1.87E-07	1.46E-05	7.10E+02

Table 14 | Mix GP, GB, MCM and SL (LH) environmental impact A1-A3 per tonne of cement: additional environmental impacts

Distribution results (A4) per tonne of cement

	ADDITIONAL ENVIRONMENTAL IMPACT INDICATORS													
	GWP - F	GWP - B	GWP - Luluc	GWP - T	ODP	AP	EP-fw	EP-fw*	EP-mar	EP-ter	POCP	ADPE	ADPF	WDP
TYPES OF CEMENT	kg CO2 eq	kg CO2 eq	kg CO2 eq	kg CO2 eq	kg CFC 11 eq.	mol H+ eq.	kg PO43- eq.	kg P eq.	kg N eq.	mol N eq.	kg NMVOCeq.	kg Sb eq.	MJ	m^3 eq.
LH/Darwin	68.33	9.77E-03	5.24E-04	6.83E+01	1.10E-05	4.21E-01	4.42E-02	2.26E-03	9.16E-02	1.02E+00	3.55E-01	2.21E-04	9.46E+02	6.07E+02
GP/Darwin	69.03	9.87E-03	5.29E-04	6.90E+01	1.11E-05	4.26E-01	4.47E-02	2.29E-03	9.25E-02	1.03E+00	3.58E-01	2.23E-04	9.56E+02	6.13E+02
SL/Port Kembla	11.40	1.63E-03	8.74E-05	1.14E+01	1.84E-06	7.03E-02	7.38E-03	3.78E-04	1.53E-02	1.70E-01	5.92E-02	3.69E-05	1.58E+02	1.01E+02
MCM/Birkenhead	82.09	1.17E-02	6.30E-04	8.21E+01	1.32E-05	5.06E-01	5.31E-02	2.72E-03	1.10E-01	1.23E+00	4.26E-01	2.66E-04	1.14E+03	7.30E+02
GP/Birkenhead	65.24	9.33E-03	5.00E-04	6.52E+01	1.05E-05	4.02E-01	4.22E-02	2.16E-03	8.74E-02	9.74E-01	3.38E-01	2.11E-04	9.04E+02	5.80E+02
GBS/Birkenhead	27.40	3.92E-03	2.10E-04	2.74E+01	4.41E-06	1.69E-01	1.77E-02	9.08E-04	3.67E-02	4.09E-01	1.42E-01	8.87E-05	3.80E+02	2.44E+02
MCM/Munster	87.83	1.26E-02	6.74E-04	8.78E+01	1.41E-05	5.42E-01	5.69E-02	2.91E-03	1.18E-01	1.31E+00	4.56E-01	2.84E-04	1.22E+03	7.81E+02
GP/Munster	31.20	4.46E-03	2.39E-04	3.12E+01	5.02E-06	1.92E-01	2.02E-02	1.03E-03	4.18E-02	4.66E-01	1.62E-01	1.01E-04	4.32E+02	2.77E+02
GP/Kwinana	57.55	8.23E-03	4.41E-04	5.76E+01	9.26E-06	3.55E-01	3.73E-02	1.91E-03	7.71E-02	8.60E-01	2.99E-01	1.86E-04	7.97E+02	5.11E+02

Table 15 | Mix GP, GB and MCM environmental impact A4 per tonne of cement: EPD potential environmental impacts

	RESOURCE USE									
	PERE	PERM	PERT	PENRE	PENRM	PENRT	SM	RSF	NRSF	FW
TYPES OF CEMENT	MJ	MJ	MJ	MJ	MJ	MJ	kg	MJ	MJ	m3
LH/Darwin	10.24	0.00E+00	1.02E+01	9.99E+02	0.00E+00	9.99E+02	0.00E+00	0.00E+00	0.00E+00	1.48E-01
GP/Darwin	10.34	0.00E+00	1.03E+01	1.01E+03	0.00E+00	1.01E+03	0.00E+00	0.00E+00	0.00E+00	1.50E-01
SL/Port Kembla	1.71	0.00E+00	1.71E+00	1.67E+02	0.00E+00	1.67E+02	0.00E+00	0.00E+00	0.00E+00	2.47E-02
MCM/Birkenhead	12.30	0.00E+00	1.23E+01	1.20E+03	0.00E+00	1.20E+03	0.00E+00	0.00E+00	0.00E+00	1.78E-01
GP/Birkenhead	9.77	0.00E+00	9.77E+00	9.54E+02	0.00E+00	9.54E+02	0.00E+00	0.00E+00	0.00E+00	1.42E-01
GBS/Birkenhead	4.11	0.00E+00	4.11E+00	4.01E+02	0.00E+00	4.01E+02	0.00E+00	0.00E+00	0.00E+00	5.95E-02
MCM/Munster	13.16	0.00E+00	1.32E+01	1.28E+03	0.00E+00	1.28E+03	0.00E+00	0.00E+00	0.00E+00	1.91E-01
GP/Munster	4.67	0.00E+00	4.67E+00	4.56E+02	0.00E+00	4.56E+02	0.00E+00	0.00E+00	0.00E+00	6.77E-02
GP/Kwinana	8.62	0.00E+00	8.62E+00	8.42E+02	0.00E+00	8.42E+02	0.00E+00	0.00E+00	0.00E+00	1.25E-01

Table 16 | Mix GP, GB, MCM and SL (LH) environmental impact A4 per tonne of cement: EPD resource parameters

	WASTE CATEGORIES		
	HWD	NHWD	RWD
TYPES OF CEMENT	kg	kg	kg
LH/Darwin	1.22E-03	9.92E+00	5.63E-06
GP/Darwin	1.23E-03	1.00E+01	5.69E-06
SL/Port Kembla	2.03E-04	1.65E+00	9.40E-07
MCM/Birkenhead	1.46E-03	1.19E+01	6.77E-06
GP/Birkenhead	1.16E-03	9.47E+00	5.38E-06
GBS/Birkenhead	4.89E-04	3.98E+00	2.26E-06
MCM/Munster	1.57E-03	1.27E+01	7.24E-06
GP/Munster	5.57E-04	4.53E+00	2.57E-06
GP/Kwinana	1.03E-03	8.35E+00	4.74E-06

Table 17 | Mix GP, GB, MCM and SL (LH) environmental impact A4 per tonne of cement: EPD waste categories

	OUTPUT FLOWS			
	CRU	MFR	MFRE	EE
TYPES OF CEMENT	kg	kg	kg	MJ
LH/Darwin	0.00E+00	0.00E+00	0.00E+00	0.00E+00
GP/Darwin	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SL/Port Kembla	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MCM/Birkenhead	0.00E+00	0.00E+00	0.00E+00	0.00E+00
GP/Birkenhead	0.00E+00	0.00E+00	0.00E+00	0.00E+00
GBS/Birkenhead	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MCM/Munster	0.00E+00	0.00E+00	0.00E+00	0.00E+00
GP/Munster	0.00E+00	0.00E+00	0.00E+00	0.00E+00
GP/Kwinana	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table 18 | Mix GP, GB, MCM and SL (LH) environmental impact A4 per tonne of cement: EPD output flow categories

	ADDITIONAL ENVIRONMENTAL IMPACT INDICATORS						
	GWP-GHG	PM	Ionising radiation	Ecotoxicity, freshwater	Human toxicity, cancer	Human toxicity, non-cancer	Soil quality
TYPES OF CEMENT	kg CO2 eq.	disease incidence	kBq U-235 eq	CTUe	CTUh	CTUh	Pt
LH/Darwin	6.71E+01	5.43E-06	4.08E-02	5.39E+02	2.02E-08	8.12E-07	2.26E+02
GP/Darwin	6.78E+01	5.49E-06	4.12E-02	5.44E+02	2.04E-08	8.21E-07	2.28E+02
SL/Port Kembla	1.12E+01	9.07E-07	6.81E-03	8.99E+01	3.38E-09	1.36E-07	3.77E+01
MCM/Birkenhead	8.07E+01	6.53E-06	4.90E-02	6.48E+02	2.43E-08	9.76E-07	2.72E+02
GP/Birkenhead	6.41E+01	5.19E-06	3.89E-02	5.15E+02	1.93E-08	7.76E-07	2.16E+02
GBS/Birkenhead	2.69E+01	2.18E-06	1.64E-02	2.16E+02	8.11E-09	3.26E-07	9.07E+01
MCM/Munster	8.63E+01	6.98E-06	5.24E-02	6.93E+02	2.60E-08	1.04E-06	2.91E+02
GP/Munster	3.07E+01	2.48E-06	1.86E-02	2.46E+02	9.24E-09	3.71E-07	1.03E+02
GP/Kwinana	5.65E+01	4.58E-06	3.44E-02	4.54E+02	1.70E-08	6.84E-07	1.90E+02

Table 19 | Mix GP, GB, MCM and SL (LH) environmental impact A4 per tonne of cement: EPD potential environmental impacts: additional environmental impacts

7 Interpretation of results

For all types of cement, clinker is the most significant contributor to the production stage GWPF emissions (54-98%), followed by site operation (1-23%).

MCM manufactured at Birkenhead has the lowest GWPF emissions because it has the lowest amount of clinker. The second lowest GWPF emissions originates from granulated blast furnace slag.

GP cement from Kwinana generates the highest GWPF impacts. This cement has the highest consumption of clinker (90 – 93%).

The GWPF emissions from the distribution of products (module A4) is relatively low in comparison to A1- A3 GWPF emissions and depends on the distance from the manufacturing sites to clients.

For LH cement production, clinker accounts for 30% of the weight while it is responsible for 73% of material related GWPF emissions. Conversely, granulated blast furnace slag contributes only 25% of the emissions while accounting for most of the weight (63%).

It is noted that clinker has the highest GWPF emissions compared to other materials.

MCM cement from the Birkenhead plant has granulated blast furnace slag as the primary material with a proportion of weight is more than 60% and is responsible for 39% of emissions. Meanwhile, clinker accounts for only 28.5% of the weight while it contributes more than 60% of emissions.

Cement kiln dust and tailings are recycled materials derived from the wastes of other production processes. BS EN 16757:2017 specifically lists these materials as co-products. These materials are considered as co-products of their production process with zero economic values and the impacts for their production process are allocated according to PCR 2019:14 Construction Products version 1.11 (co-produced goods, multi-output allocation). Therefore, the environmental impacts associated with the production of these materials are considered to be zero and only include transport impacts.

Carbon emissions across A1-A4

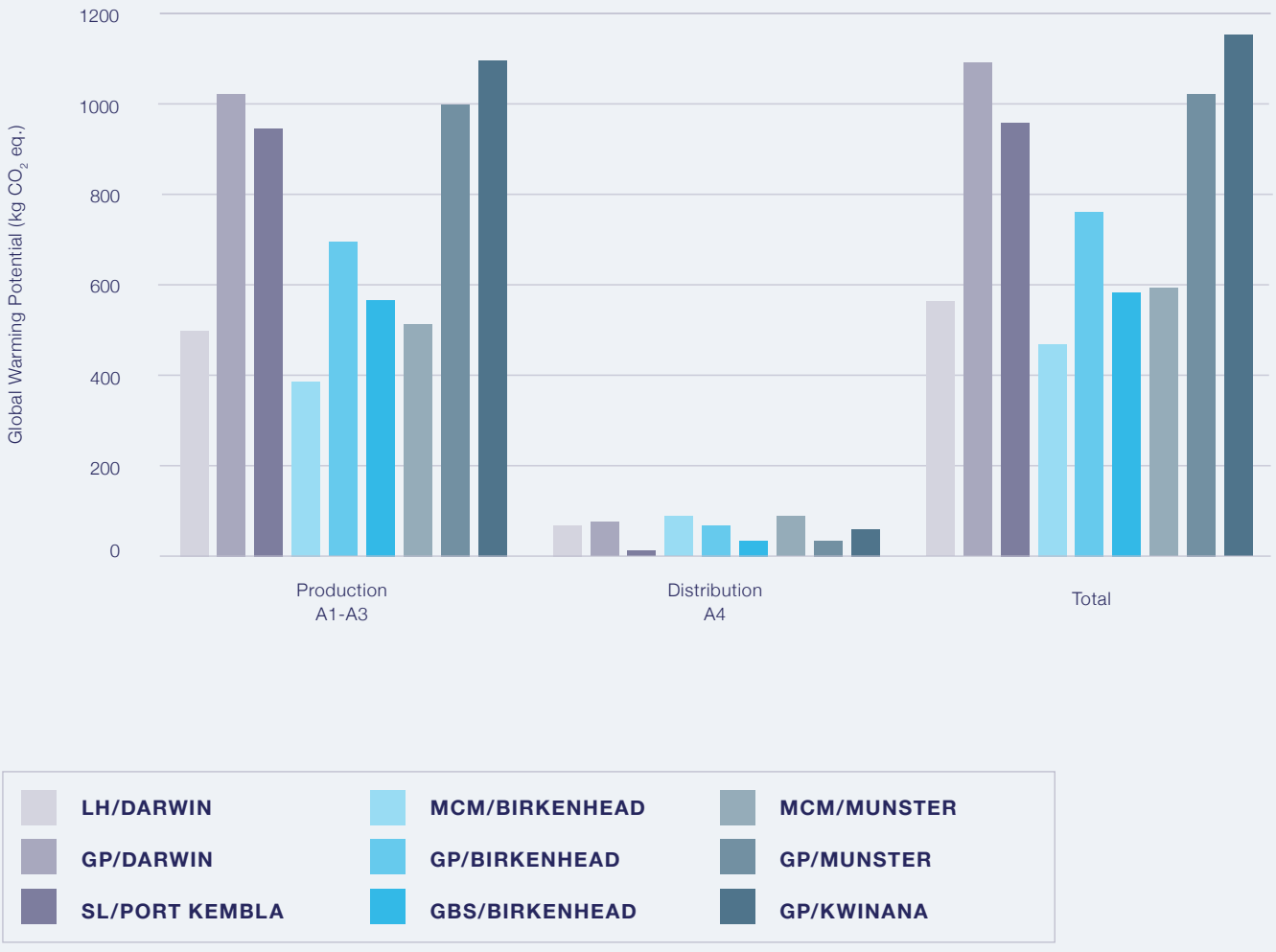


Figure 3 | GWPF for modules A1-4 (per tonne) for cement mixes included in this EPD

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